New Biomass Burning Smoke Emissions Dataset Fills Gap between Previous Estimations and Expected Values

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Fires burn extensively in most vegetated parts of the world. Smoke from biomass burning contributes a major portion of the annual carbon emissions to the atmosphere. Thus, an accurate smoke emissions inventory is imperative to correctly understand the impacts of biomass burning on the global climate system and regional environmental dynamics.

A major effort to create a new emissions dataset for this very purpose was undertaken during the past several years. The result is the FEER (Fire Energetics and Emissions Research) emissions product, available at http://feer.gsfc.nasa.gov/data/emissions/. This is a globally gridded product at 1° ×1° resolution that is derived from satellite measurements of fire radiative power (FRP) and aerosol optical depth (AOD), in conjunction with model-assimilated wind fields. The building block for the product are emission coefficients that relate FRP directly to smoke emission rate (Fig. 1).

The generated FEER smoke aerosol emissions (Fig. 2 & 3) are higher than those of several other emission inventories (e.g. GFED, GFAS), by a factor of 2-4. This agrees with the typical adjustment factors that models apply to make these other inventories consistent with global AOD distributions from satellites.

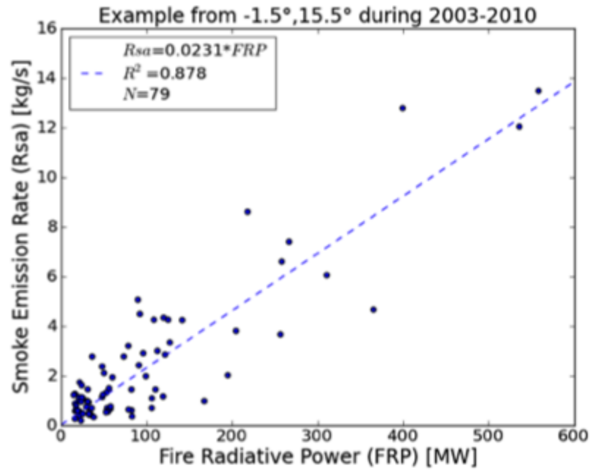

Figure 1: The FEER algorithm is based on observed linear relationship between a fire's radiative energy release rate or power (FRP) and smoke aerosol emission rate (Rsa).

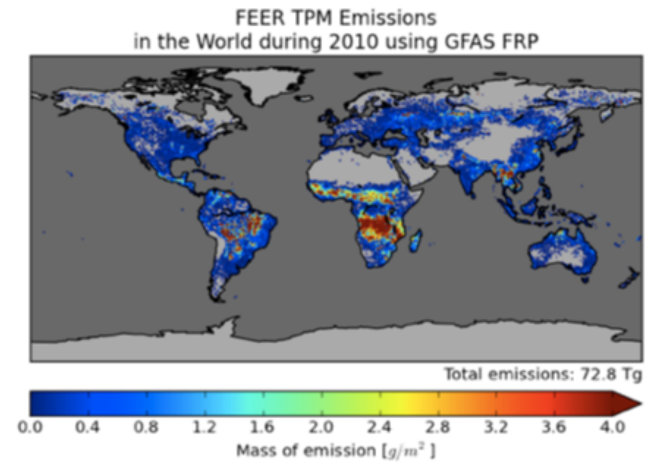

Figure 2: The FEER emissions product has good global coverage. Major burning regions are clearly in Central and Southern African regions, Central S. America and SE Asia.

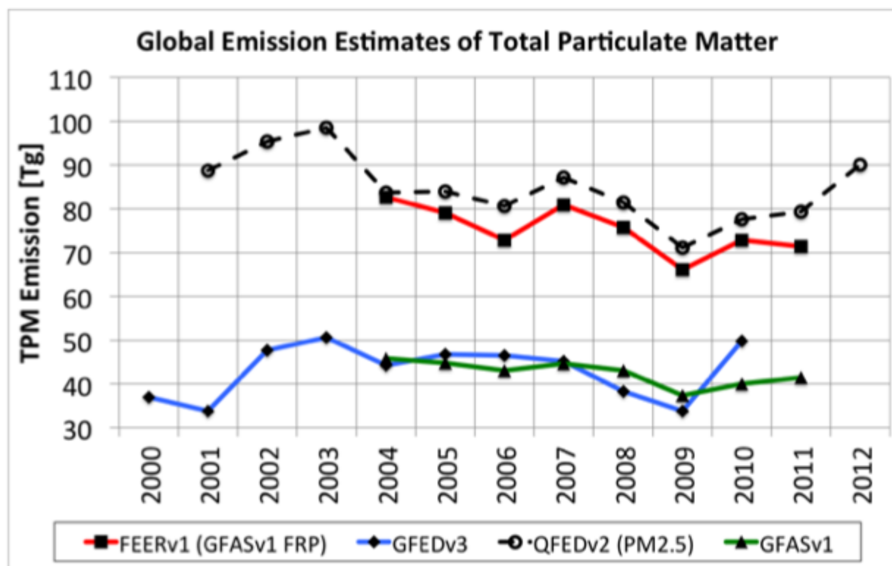

Figure 3: Comparison of several smoke emission datasets commonly used in many science studies with our own FEER emissions. Note that FEER captures significantly more smoke than GFED and GFAS.

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Data Sources:

•FEER Coefficients of Emission Product (http://feer.gsfc.nasa.gov/data/emissions/)
- MODIS Fire Radiative Power Product (MOD14/MYD14, http://modis-fire.umd.edu/)
- MODIS Aerosol Product (MOD04_L2/MYD04_L2, http://modis-atmos.gsfc.nasa.gov/MOD04_L2/)
- MERRA Reanalysis Dataset (inst3_3d_asm_Cp, http://disc.sci.gsfc.nasa.gov/mdisc/data-holdings/merra/inst3_3d_asm_Cp.shtml)

•GFAS Fire Radiative Power Data and Emissions Product (v1.0, https://www.gmes-atmosphere.eu/services/gac/fire/)
•GFED Emissions Product (v3.1, http://www.globalfiredata.org/)
•QFED Emissions Product (v2.4, http://geos5.org/wiki/index.php?title=Quick_Fire_Emission_Dataset_%28QFED%29)

Technical Description of Figures:

Figure 1: Scatter plots of smoke emission rate (R_{sa}) against fire radiative energy release rate or power (FRP or R_{fre}) derived from both Terra and Aqua MODIS observations during the period 2003–2010 for a $1^\circ \times 1^\circ$ grid cell centered at -1.5° latitude and 15.5° longitude.
Figure 2: FEER.v1 estimates of aerosol total particulate matter (TPM) for all of 2010 on a $0.5^\circ \times 0.5^\circ$ resolution global grid. These values are generated by multiplying coefficients of emission (C_e) with fire radiative power (FRP), using the FEER.v1 C_e product combined with the GFASv1.0 FRP monthly data.
Figure 3: Time series of yearly total particulate matter (TPM) emissions in Tg from 2000-2012 for FEER.v1, GFED.v3, QFED.v2 and GFAS.v1. QFED.v2 values (dotted line) are for $PM_{2.5}$ (i.e. particulate matter with aerodynamic diameter less than 2.5 microns).

Scientific significance: Smoke emission have long been calculated by bottom-up approaches, using burned area, fuel content or biomass density, and burn efficiency data, along with experimentally determined emission factors to estimate smoke emissions for any given area. It is easy to see how the uncertainties for these many parameters compound very quickly, with the result that modelers find these emissions to be severely underestimated when their results are compared with satellite aerosol distributions. Besides, the generalized emission factors used in these inventories do not offer much spatial variability. The FEER emissions product is unique in that it directly relates the two quantitative datasets of interest: fire radiative power (FRP) and smoke emissions and provides emission coefficients at a comparatively high spatial resolution ($1^\circ \times 1^\circ$) that is easily amenable to verification and validation.

Relevance to future science and NASA missions: Fire is a major contributor of carbon emissions to the climate system, and at a time when climate change is of high scientific significance, an accurate representation of biomass burning emissions is desperately needed to adequately address current and future challenges targeted by various NASA missions related to land-cover change dynamics, carbon emissions, atmospheric composition, and climate. For instance, this FEER emissions product is currently being used in a major interdisciplinary study on how fires impact the devastating droughts in sub-Saharan Africa.